Chameleon's tongue strike inspires fast-acting robots

October 29 2019, by Nicole Pitti

Ramses V. Martinez, an assistant professor at Purdue University, and his students created this cover image. Chameleon tongue strikes inspired the team to create soft robots that catch live insects in the blink of an eye. Credit: Ramses V. Martinez/Purdue University

Chameleons, salamanders and many toads use stored elastic energy to launch their sticky tongues at unsuspecting insects located up to one-and-a-half body lengths away, catching them within a tenth of a second.

Ramses Martinez, an assistant professor in Purdue's School of Industrial Engineering and in the Weldon School of Biomedical Engineering in Purdue University's College of Engineering and other Purdue researchers at the FlexiLab have developed a new class of entirely soft robots and actuators capable of re-creating bioinspired high-powered and high-speed motions using stored elastic energy. These robots are fabricated using stretchable polymers similar to rubber bands, with internal pneumatic channels that expand upon pressurization.

The elastic energy of these robots is stored by stretching their body in one or multiple directions during the fabrication process following nature-inspired principles. Similar to the chameleon's tongue strike, a pre-stressed pneumatic soft robot is capable of expanding five times its own length, catch a live fly beetle and retrieve it in just 120 milliseconds.

"We believed that if we could fabricate robots capable of performing such large-amplitude motions at high speed like chameleons, then many automated tasks could be completed more accurately and in a much faster way," Martinez said. "Conventional robots are usually built using hard and heavy components that slow down their motion due to inertia. We wanted to overcome that challenge."

This technology is published in the Oct. 25 edition of *Advanced Functional Materials*. A video showing this insect-catching robot:

Many birds, like the three-toed woodpecker, achieve zero-power perching using the elastic energy stored in the stressed tendons at the back of their legs, allowing them to not fall off a perch when asleep. The anatomy of these birds has served as an example to enable the fabrication of robotic grippers capable of zero power holding up to 100 times their weight and perching upside down from angles of up to 116 degrees.

The conformability of the soft arms of these grippers to the gripped object maximizes contact area, enhancing grasping and facilitating high-speed catching and zero-power holding. A video showing how these bird-inspired soft robotic gripper catching a ball moving at 10 millimeters per second in only 65 milliseconds is available below:

A video showing how these grippers can perch upside down from angles up to 116 degrees:

Some plants also know how to exploit elastic energy to achieve high-speed motion using "trap mechanisms." The Venus flytrap uses the elastic energy stored in its bistable, curved leaves to rapidly close on prey exploring their inner surface.

Inspired by the trap mechanism of the Venus flytrap and studying how lizards catch insects, the Purdue team created a soft robotic Venus flytrap, which closes in only 50 milliseconds after receiving a short pressurized stimulus. A high-speed camera video showing the closure in a snap of this soft robotic Venus flytrap:

Martinez said these new pre-stressed soft robots have several significant advantages over existing soft robotic systems. First, they excel at gripping, holding and manipulating a large variety of objects at high speed. They can use the elastic energy stored in their pre-stressed elastomeric layer to hold objects up to 100 times their weight without consuming any external power.

Their soft skin can be easily patterned with anti-slip microspikes, which significantly increases their traction and enables them to perch upside down over prolonged periods of time and facilitates the capture of live prey.

"We envision that the design and fabrication strategies proposed here will pave the way toward a new generation of entirely soft robots capable of harnessing elastic energy to achieve speeds and motions currently inaccessible for existing robots," Martinez said.

Provided by Purdue University

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